Green IS: Are We Still Thinking in Mere Economic Imperatives or Are We Striving for Eco-Effectiveness?

Full Paper

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Abstract

Organizations are under increasing pressure to account for their environmental footprint and to adopt environmental sustainable practices, and information systems can support organizations in becoming more environmentally sustainable. Through the analysis of expert interviews with eleven representatives from organizations concerned with environmental sustainability, and drawing on a conceptual model of information systems and ecological sustainability, we provide evidence that these organizations see key capabilities of information systems in automating, informing, and transforming to support goals related to eco-efficiency, eco-equity, and eco-effectiveness. However, our analysis also suggests that there is still little awareness of the potential of information systems in fundamentally transforming business models and business processes towards eco-effectiveness as the ultimate goal of environmental protection.

Keywords

Green IS, Environmental sustainability, Expert interviews, Sustainable organization.

Introduction

Environmental sustainability is the dominant topic of the 21st century and business organizations must react to this new challenge (Watson et al. 2012). In order to be sustainable, organizations have to strive for eco-efficiency, eco-equity, and eco-effectiveness (Dyllick et al. 2002). While eco-efficiency merely reflects environmental impact in economic terms and eco-equity describes a principle of environmental responsibility that is part of the organization's value system, only eco-effective behavior can indeed end ecological degradation (Chen et al. 2008). While empirical research provides ample evidence that organizations indeed use information technology to support environmental sustainability (e.g. Seidel et al. 2013), it is questionable whether they fully capitalize on the transformative power of information systems (IS) to realize eco-effectiveness. We are thus interested in how organizations see the potential of green IS to accomplish eco-efficiency, eco-equity, and indeed eco-effectiveness—and what the reasons are for their choices. It has been suggested that IS can contribute to these goals through their capabilities of automation, information, and transformation (Chen et al. 2008). We thus intend to shed some light on how specifically the capabilities of IS support the different goals. To do so, we empirically attend to how organizations use these capabilities to pursue ecological sustainability, and we investigate whether IS are indeed seen and used as means to developing eco-effective behaviors instead of merely increasing eco-efficiency and eco-equity:[1]

[1] Please note that the study started exploratory in nature, and the focus on eco-effectiveness evolved during the analysis of the interviews. We started our interviews with general questions about the role of information systems in

> *RQ: How do organizations capitalize on automation, information, and transformation capabilities of information systems in order to accomplish environmental goals in terms of eco-efficiency, eco-equity, and eco-effectiveness?*

To explore the topic from different perspectives, we conducted expert interviews with eleven respondents whose daily work is concerned with environmental sustainability. Our work applies a previously published theoretical lens (Chen et al. 2008) to contribute to understanding green IS and the role of IS in supporting environmental sustainability in organizations.

The results from our empirical study provide some evidence that organizations indeed identify IS capabilities to automate, inform, and transform in the context of environmental sustainability, and we relate these abilities to the specific sustainability goals of eco-efficiency, eco-effectiveness, and eco-equity.

We proceed as follows. First, we present the research background, highlighting the goals of eco-efficiency, eco-effectiveness, and eco-equity as well as the three key capabilities of IS to automate, inform, and transform. Next, we describe the research method and data we collected. The findings section ensues. We then discuss the results of our study and conclude with the limitations and contribution of our study.

Research Background

Based on the Brundtland definition of sustainable development (World Commission on Environment and Development 1987), environmental sustainability is defined as "stakeholder behavior impacting on the natural environment that meets the needs of the present without compromising the ability of future stakeholders to meet their own needs" (Elliot 2011), a goal that can be accomplished through living and acting within the limitations of the natural environment (Goodland 1995). Only as much resources can be consumed as the ecosystem can reproduce or substitute, and only as much emissions can be released as the environment can absorb and assimilate (Goodland 1995). We first describe the environmental goals of eco-efficiency, eco-effectiveness, and eco-equity (Dyllick et al. 2002), before we then proceed to the capabilities of IS in terms of automation, information, and transformation (Chen et al. 2008).

Environmental Goals

Organizations often see **eco-efficiency** as the first step towards environmental sustainability (Dyllick et al. 2002). Eco-efficiency implies the delivery of services and goods at competitive prices, while decreasing the environmental impact during their lifecycle (DeSimone et al. 1997), thus focusing on *doing more with less*. Eco-efficiency is often motivated by cost reduction goals (Chen et al. 2008).

Eco-equity focuses on future generations that will live in the environment we leave behind, and thus with the damages caused by our consumption (Chen et al. 2008; Dyllick et al. 2002). In the context of business organizations, eco-equity describes a change of values and implies a stronger focus on environmental issues (Chen et al. 2008).

The ultimate goal of environmental sustainability is **eco-effectiveness**—that is, indeed ending environmentally harmful activity (Chen et al. 2008). Eco-efficiency alone is not sufficient due to three characteristics of natural resources: (1) non-substitutability, (2) non-linearity, and (3) irreversibility (Dyllick et al. 2002). While we are able to substitute certain natural resources, and future generations might be able to substitute further natural resources, it is unlikely that we will be able to substitute *all* natural resources (Dyllick et al. 2002). Non-linearity highlights that natural processes might develop in a non-linear manner—consider a lake that can absorb nutrient for a long time (Dyllick et al. 2002). However, once the lake contains a certain level of algae, its ecosystem collapses. Irreversibility implies that the deterioration of the ecosystem might be definite, for instance, the loss of biodiversity (Dyllick et al. 2002).

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environmental sustainability transformations. The research question evolved during the study, which is legitimate in qualitative, exploratory research (Creswell, 2003).

Green Information Systems

It is now commonly accepted in the academic IS field that IS can increase environmental sustainability through enabling sustainable practices (Dedrick 2010; Elliot 2011; Melville 2010; Seidel et al. 2010; Seidel et al. 2013). The corresponding research stream, often labeled *green IS,* focuses on "the design and implementation of IS that contribute to sustainable business processes" (Boudreau et al. 2008). IS as formal socio-technical systems that transmit, process or store information (Piccoli 2012), where information technology (IT) represents the technical subsystem, can support the three eco-goals through (1) automating, (2) informing, and (3) transforming (Chen et al. 2008). These three roles originate from CEO's basic assumptions about IT identified by Schein (1992).

Automation refers to the replacement of human labor through IT (Chen et al. 2008; Dao et al. 2011; Schein 1992). Human labor is seen as manual, unreliable, and expensive, while IT is considered automated, reliable, and less costly (Chen et al. 2008; Schein 1992). Advantages associated with automation are reduced costs (Chen et al. 2008), faster, more efficient, more accurate execution of tasks (Dao et al. 2011), and higher quality (Schein 1992). In the context of environmental sustainability, automation leads to higher eco-efficiency (Chen et al. 2008).

The **informing** capability of IS relates to how external and internal stakeholders on diverse organizational levels are provided with relevant information (Chen et al. 2008). Indeed, managers might see IS as an "ultimate management control tool" (Schein 1992), and IS provide more transparency to employees, customers, and suppliers (Chen et al. 2008; Schein 1992). By informing and educating stakeholders to raise awareness of environmental problems, IS can support the achievement of eco-equity (Chen et al. 2008). Examples include IS for monitoring environmental sustainability initiatives along supply chains and making collaborative decisions (Meacham et al. 2013), for analyzing the environmental footprint of a business (Molla 2009), for assessing supplier sustainability (Molla 2009), for tracking of environmental products (Boudreau et al. 2008), for comprehensive ordering for less transportation (Bengtsson et al. 2011), for providing information to customers (Boudreau et al. 2008), for virtualizing information (Hasan et al. 2013), or for enabling reflective disclosure and information democratization (Seidel et al. 2013).

IS have the potential to **transform** organizations by fundamentally changing the nature of products, processes, and the relationships with customers and suppliers, thereby creating eco-effectiveness (Chen et al. 2008). Organizations are enabled to develop new products, services, business processes, and market positions (Dao et al. 2011). Tools for remote work such as videoconferencing are prominent examples (Boudreau et al. 2008; Hasan et al. 2013; Ijab et al. 2012; Seidel et al. 2013). Furthermore, existent products can be replaced by digital, less environmentally harmful products, for instance e-papers (Ijab et al. 2012).

Research Method

Using expert interviews, a common form of qualitative, exploratory inquiry in the academic IS discipline (Bandara et al. 2007), we aim to investigate how organizations use capabilities of automation, information, and transformation in order to accomplish eco-goals in terms of efficiency, equity, and effectiveness. As indicated, we are specifically interested in how far, and for what reasons, organizations indeed pursue eco-effectiveness.

For our study sample, we selected employees that are concerned with environmental sustainability in their daily work. As our aim is to explore the use of IS from different perspectives, we included both employees who are concerned with achieving environmental sustainability within their organizations as well as those helping their customers in achieving environmental sustainability.

We interviewed a total of eleven experts (Table 1), six via telephone and five face-to-face. The average length of phone interviews was approximately 30 minutes and the average length of our face-to-face interviews was approximately 60 minutes. Expert 8 and Expert 9 work for the same company and were interviewed in one face-to-face meeting. All interviews were conducted by the first author of this study.

Expert ID	Type	Position	Company
Expert 1	Telephone	Consultant	Large consulting company
Expert 2	Telephone	Consultant	Independent consultant
Expert 3	Telephone	Consultant	Large consulting company
Expert 4	Face-to-face	IT-Manager	Local utility company
Expert 5	Face-to-face	Product manager	Heating equipment construction company
Expert 6	Telephone	Consultant	Large consulting company
Expert 7	Face-to-face	Energy consultant	Local consulting firm, related to utility company
Expert 8	Face-to-face	IT manager	Logistics provider
Expert 9	Face-to-face	Sustainability officer	Logistics provider
Expert 10	Telephone	Sustainability coordinator	International consulting company
Expert 11	Telephone	Corporate sustainability office member	Multinational conglomerate company

Table 1. Summary Details of Interviewed Experts

The focus of the semi-structured, open-ended interviews was on how IS can enable environmental sustainability in organizations, and the interviewer asked for their experiences with using IS in the context of environmental sustainability. All experts were native German speakers and all interviews were conducted in German, audio taped, and fully transcribed. In our data analysis, we drew on the procedures described by Meuser et al. (1991) and recently applied in IS research by Menges et al. (2014). In order to analyze the transcribed and paraphrased interviews, we developed first codes (e.g., route optimization, reduced paper consumption) through a process of open coding. The resultant codes were then compared and synthesized across the interviews. The theoretical lens was applied to group codes and identify automation, information, and transformation capabilities of IS. Through the analysis, we were further able to relate these capabilities to the triple goals of eco-efficiency, eco-equity, and eco-effectiveness. The coding was conducted by the first author of this study and then discussed with the second author in order to corroborate the findings and ensure plausibility of codes. We used the qualitative data analysis tool NVivo 10.

In what follows, we provide a brief overview of the experts we interviewed.

Expert 1

Expert 1 has worked at an international consulting firm for ten years, where he has built up a dedicated business unit for sustainability. The business unit supports customers in their sustainability reporting as well as in other environmentally sensitive areas, for instance, strategic decision-making or supply chain management. Expert 1 sees a twofold role of IT in the context of environmental sustainability. On the one hand, IT is a tool to promote sustainability through supporting monitoring, reporting, and measuring. On the other hand, IT supports the management of sustainability through optimization in the context of resource consumption. This view is consistent with the dual role of sensemaking and sustainable practicing previously described in the literature (Seidel et al. 2013).

Expert 2

Expert 2 is a freelance process consultant. His work focuses on sustainability reporting. Expert 2 identifies a well-grounded informational basis including the impact of process change as the prerequisite to manage sustainability.

Expert 3

Expert 3 works for an international IT consulting company and has been interested in the sustainability topic for several years. Expert 3 highlights three aspects of how IT can support sustainability: (1) through IT products that help customers to decrease their ecological footprint, such as cloud storage, (2) through IT systems that optimize internal processes, and (3) through sharing platforms that allow their users to share resources, for instance, accommodation or cars, with potentially unknown customers. Expert 3 further experiences IT as permeating daily life, and thus sees technologies such as email, videoconferencing, or e-learning as being used in both private and professional life.

Expert 4

Expert 4 is the IT manager of a small utility company that focuses on environmental sustainability and energy management. While his main interest is in reducing the direct impact of using IT, he has also been responsible for implementing several IT supported processes with the explicit goal of reducing resource consumption. Importantly, the interviewee points out that the majority of changes is not initiated by sustainability initiatives, but are indeed outcomes of other types of organizational change, for instance, increasing number of employees.

Expert 5

Expert 5 is a product manager of a large company for heating and cooling solutions. The company's portfolio focuses on products that support sustainability. IT is a substantial part of these products and supports sustainability in three ways: (1) through coordination and optimization of household heating systems, (2) through enabling monitoring and thus changing user behavior, and (3) through supporting the control of large heating supply systems.

Expert 6

Expert 6 is an employee at an international auditing firm. His focus is on reviewing and verifying sustainability reports of the company's customers. This respondent sees a major role of IT in reporting sustainability figures in a reliable and easily verifiable way.

Expert 7

Expert 7 is an energy consultant who works for a small subsidiary of a local utility provider. Specifically, Expert 7 has developed an Excel-based energy cockpit that collects data about sustainability indicators, mainly related to energy, but also including waste or CO_2 emissions. Expert 7 sees this cockpit, and the informational basis it provides, as a necessary precondition to realize sustainability goals.

Experts 8 and 9

Expert 8 and Expert 9 work for the same logistics provider, where Expert 8 is the IT manager and Expert 9 is responsible for health, sustainability, and quality. Sustainability is an integral part of their company's vision. Despite the considerably high carbon footprint caused by their core business, the company aims to accomplish sustainability, both in terms of social well-being and environmental protection. The main transportation means are trucks. The organization displays the actual CO_2 emissions of the available means of transportation through a CO_2 emission calculator. Perusing telemetry data, the company adopts those routes that have lesser environmental impact in terms of carbon emissions. Nevertheless, the focus is typically on economic goals, and achieving environmental goals is a rather complementary goal.

Expert 10

Expert 10 is responsible for the internal sustainability management of an international consulting company. The company has implemented a green awareness platform informing the employees about the company's sustainability initiative, planned events, on how to act sustainable—both at the workplace and at home—and provides background information regarding the relevance of certain topics. Due to their business activity, the company's main source of carbon emissions is business traveling. The company has taken various actions to reduce related CO_2 emissions such as increasing the use of videoconferences.

Expert 11

Expert 11 works at the corporate sustainability office of a multinational conglomerate company for industrial and consumer goods. This respondent highlights that the company's biggest potential to

positively influencing the environment is through its products. Internally, IS help the organization create transparency through reporting as well as through consolidating and analyzing different data sources (e.g. Internet of things).

Findings

As we interviewed both experts responsible for internal transformations and those that focus on selling sustainability-relevant products to customers, our analysis yielded a broad picture on how IS are used for environmental sustainability. While some interviewees provided quite detailed descriptions of specific technologies, others focused on the general role of IT in achieving environmental sustainability.

In what follows, we describe the results of our analysis based on the three abilities of IS to automate, inform, and transform, and under consideration of the triple goals of eco-efficiency, eco-equity, and eco-effectiveness.

Automate

The ability of IS to automate processes in the context of environmental sustainability was mentioned in three out of the ten interviews (Expert 1, Expert 5, Expert 11). Specifically, the three organizations use IS to reduce resource consumption. Expert 1 and Expert 11, for instance, refer to production processes where control systems help reduce the energy consumption:

> [..] IT as a major topic in the context of resource consumption, the active management of sustainability, means that you optimize so that you can take advantage of synergies, which then is supported by appropriate systems (Expert 1/translated).

Expert 1 and Expert 5 mention facility management, where IS can help reduce energy consumption of buildings. Expert 5, for instance, mentions the complexity of heating systems, which could not be managed without IS:

> I essentially have two, even three energy sources, and to coordinate these is insanely difficult. You can see that sensors are everywhere here. I have 14 sensors and then I have several switches that switch the hydraulics. And the whole thing is already difficult to coordinate, but in addition, you also have to optimize it, with IT, with the software (Expert 5/translated).

Our data thus suggests that automation capabilities of IS are primarily seen to increase eco-efficiency; that is, the organization operates under the same, established business model, thereby pursuing environmental sustainability in a way that is consistent with the organizations economic success (Chen et al. 2008). Table 2 provides an overview.

Technology	**Automation capability**	**Effect**	**Empirical evidence**
Production control system	Optimization, using synergies	Eco-efficiency in terms of reduced resource consumption	Expert 1, Expert 11
Facility management system	Automation and optimization of the coordination of energy supply and demand	Eco-efficiency in terms of reduced energy consumption	Expert 1, Expert 5, Expert 11

Table 2. Findings Related to Automation Capabilities

Inform

The capability of IS to inform was highlighted in eight out of ten interviews. The focus was on the collection, analysis, and reporting of sustainability related data. Expert 1 mentions that IS can be a tool to promote sustainability in organizations through supporting monitoring and reporting. Moreover, Expert 2 emphasizes the importance of information for sustainability management:

> [..] An important requirement, a prerequisite for sustainability within the company, from a management point of view, is just a well-grounded information base (Expert 2/translated).

This expert thus points to the importance of quantifying the impact of unsustainable or sustainable behavior. The company of Expert 1 has developed a tool that quantifies and shows environmental aspects.

Our data provides several examples of how the capability to inform is used, including for product lifecycle assessment (Expert 6), stakeholder management with regards to sustainability expectations (Expert 1), ISO 50001 management system to control energy and ecological data (Expert 7), or the calculation of emissions for certain transport means (Expert 8 and Expert 9).

Expert 7 notes that reporting does not lead to business value per se. Organizations could use the data to support organizational decision-making, for instance. This is consistent with the opinion of Expert 3, who sees opportunity to use environmental data for strategic decision making related to the company's product portfolio:

> [..] To use the data pool for a strategic decision in relation to the product portfolio. If I find out that during the production of the product x very much CO_2 and energy is consumed, then I can maybe think about whether I put my focus on another product or on a new development (Expert 3/translated).

Expert 10 describes an internal intranet platform that aims at creating awareness for sustainability. The platform provides general information about sustainability, gives background information related to its relevance, and on how to act sustainably. The company further uses a travel portal, where, for each trip, employees are provided with different transportation alternatives. Besides the cost, employees also see the estimated traveling time as well as the associated carbon emissions. Similarly, Expert 8 describes the carbon emission calculator as a first step towards sustainability by raising awareness.

The information provided by IS does not only help raise awareness with the aim to change user behavior, but also optimize processes. For instance, IS help optimize routes (Expert 5), truck space utilization, or maximum speed for trucks (Expert 8 and 9):

> For this purpose, actually only through IT that we have realized it. As before, at a maximum during talks, but there's always everything fine (Expert 9/translated).

Besides their capability of raising awareness by presenting data and information, the interviewees also mentioned the role of IS for comparison between practices and products. For instance, the product developed by Expert 5 provides users a comparison of consumption with historic values, or with values from comparable households.

> And that should be in a way a motivation for that customer or for the operator to optimize their system. This is the indirect way, because that means then influencing the user behavior, as it is said, you were not good today, you did not behave well, you needed more in proportion than last time (Expert 5/translated).

In addition, Expert 6 and Expert 7 describe tools that allow for benchmarking. Expert 6 focuses on benchmarking with competitors, while Expert 7 compares actual and previous values of the same customer. The tool developed by Expert 6 mainly uses the capability of IS to handle big amounts of data, while the tool described by Expert 7 presents the comparison under consideration of external factors such as outside temperature to consider the number of effective heating days, for instance.

Finally, the ability to inform is not only used for evaluating one's own performance, but also for monitoring the performance of people or machines. For instance, Expert 8 and Expert 9 mention the use of IS to monitor the driving behavior of truck drivers in order to provide feedback and make them change their behavior. Expert 5 describes how IS are used to monitor district heating plants and to give automated alarms if certain thresholds are exceeded.

To summarize, during the interviews the experts mentioned several usage scenarios, all of which are based on the ability of IS to capture, store, analyze, and present information, primarily targeted at eco-equity and eco-efficiency. Table 3 provides an overview.

Technology	Information capability	Effect	Empirical evidence
Environmental management tool	Date capturing, monitoring and reporting	Eco-equity in terms of increased transparency and informed decision making, leading finally to reduced CO_2 emissions	Expert 1, Expert, 2, Expert 3, Expert 7, Expert 11
Stakeholder management tool	Data collection and analysis	Eco-equity in terms of inclusion of stakeholder	Expert 1
Impact quantification tool	Analysis	Eco-equity in terms of informed decision making	Expert 1
Green awareness platform	Presentation of information	Eco-equity in terms of awareness among employees	Expert 10
Travel portal	Presentation of environmental related information	Eco-equity in terms of awareness among employees	Expert 10
Decision support system	Data collection and storage	Eco-equity in terms of informed strategic decision making	Expert 3
Route optimization	Analysis	Eco-efficiency in terms of reduced emissions	Expert 5, Expert 8, Expert 9
Monitoring tool	Monitoring and data analysis	Eco-efficiency in terms of reduced energy consumption through changed user behavior	Expert 5
Production control system	Monitoring	Eco-efficiency in terms of optimized production processes	Expert 5
Life cycle assessment tool	Calculation and analysis	Eco-equity in terms of adjusted objectives	Expert 6
Driving simulator	Simulation	Eco-efficiency in terms of more ecological driving behavior	Expert 7
CO_2 calculator	Calculation	Eco-equity in terms of increased awareness	Expert 8, Expert 9
Telemetry data monitoring system	Data handling and monitoring	Eco-efficiency in terms of improved driving behavior	Expert 8, Expert 9

Table 3. Findings Related to Information Capabilities

Transform

Four of the experts highlight on the ability of IS to transform, thereby mentioning three categories. First, IS transform office work, second, they might transform production, and third, IS are key component of some sustainable products. Four experts mentioned that the digitalization—and thus fundamental transformation—of their office work through videoconferences (Expert 3, Expert 10) and digital documents (Expert 3, Expert4, Expert 11) lead to less CO_2 emissions and less paper consumption. However, Expert 3 also remarks:

> [..] I can think of very many such small things that are maybe not so small, but already so obvious that I would not have thought about it directly (Expert 3/translated).

Speculating about future developments, Expert 11 sees a huge potential of IS to transform factories towards digital factories, thus leading to more efficiency, but also contributing to eco-effectiveness. He mentions simulation as an already used approach that has transformed, for instance, the process of prototyping as organizations can consider computer simulations instead of building prototypes.

In addition, the experts mentioned a few products that support sustainability and that require IS. These are smart grids (Expert 11), cloud storage, and sharing platforms (Expert 3). Table 4 provides an overview.

Technology	**Transformation capability**	**Effect**	**Empirical evidence**
Video- and telephone conference system	Virtual communication	Eco-effectiveness in terms of changed meeting behavior	Expert 3, Expert 10
Smart Grid	Management of energy supply fluctuation	Eco-efficiency in terms of improved energy management	Expert 11
Digital document	Digitalization of documents	Eco-effectiveness in terms of replacing print-outs through digital documents	Expert 3, Expert 4, Expert 11
Digital office	Digitalization of documents and virtual communication	Eco-effectiveness in terms of reduced need to travel and commute, thus reducing CO_2 emissions	Expert 3, Expert 11
Cloud storage	Centralized data storage	Eco-efficiency in terms of reduced CO_2 emissions	Expert 3

Table 4. Findings Related to Transformation Capabilities

Discussion

In this paper, we reported on the analysis of ten interviews on the role of IS in the context of environmental sustainability in organizations. Specifically, we analyzed our data through the theoretical model proposed by Chen et al. (2008). Our interest is to examine in how far the capabilities of IS to automate, inform, and transform are perceived and enacted, and how the experts see their influence on the triple eco-goals of eco-efficiency, eco-equity, and eco-effectiveness. Specifically, we are interested in how far organizations indeed use IS to accomplish eco-effectiveness, that is, true change towards environmental sustainability in the sense of non-environmentally-harmful behavior.

Through our analysis, we found evidence for the triple goals of eco-efficiency, eco-equity, and eco-effectiveness based on the all three capabilities of automation, information, and transformation, where information was the most frequently mentioned one. From our analysis, we can see that eco-equity and eco-efficiency appear to be the most prominent goals pursued in current sustainability initiatives.

First, our findings suggest that organizations indeed use IS to focus on **eco-efficiency**—examples include the use of IS for automation with the explicit goal of reducing resource consumption as well as IS for information that provide an overview of alternatives with different ecological impact. However, it is surprising to see that only three out of the eleven experts explicitly mentioned the role of automation in the context of environmental sustainability, for instance, to reduce resource consumption and energy consumption. This might be explained by the historically prevailing use of IS to increase the twin goals of productivity (increased output with same amount or resources) and efficiency (same output with less resources); consequently, these systems are not necessarily seen as primary contributors to environmental sustainability as they help pursue economic goals. Information capabilities, such as monitoring people or systems and optimizing their behavior also support eco-efficiency. Our findings thus confirm that organizations use IS in order to accomplish eco-efficiency, as eco-efficiency is typically

directly related to reducing costs and thus reflects ecological impact from an economic perspective (Chen et al. 2008; Dyllick et al. 2002).

Second, we found evidence that IS are used to foster **eco-equity.** Specifically, informational capabilities related to reporting, organizational decision-making, and raising awareness support eco-equity. The experts saw these capabilities as important pre-requisites to manage environmental sustainability in the organization. Expert 3 explicitly said that sustainability performance management supports the organizations in reducing CO_2 emissions.

Third, there is some evidence for the transformational capabilities of IS leading to **eco-effectiveness.** The digital office provides opportunities to work remotely, and thus aims at reducing emissions through less travelling and commuting, and reducing paper consumption through less printing and less paper-based forms. Importantly, we also found evidence for the role of IS in developing new products that are more environmentally friendly than existing ones.

However, most solutions that are currently used and discussed (e.g., sharing platforms, smart grids, cloud computing, or indeed systems for environmental monitoring) aim to use existing resources more efficiently, but still typically consume non-renewable resources. New IT products thus do not necessarily lead to eco-effectiveness. Hence, when promoting the ability of IS to transform, special emphasis should be on the impact of the resulting tools on the environment.

Our analysis provides some empirical evidence that IS indeed provide capabilities of automation, information, and transformation in the context of environmental sustainability. Still, there is little evidence that IS are indeed (extensively) used in order to transform business models and to seek "an ultimate solution for ecological problems" (Chen et al. 2008). Specifically, the role that IS play in transforming organizations beyond just higher efficiency and equity is not yet entirely clear.

Based on the sample we studied, and drawing on the definition of green IS proposed by Watson et al. (2010), we suggest the following conjectures:

> **Conjecture 1:** Information systems rather are seen as contributors to environmental sustainability in terms of eco-efficiency and eco-equity than as enablers of fundamental organizational transformation towards eco-effectiveness.
>
> **Conjecture 2:** To fully capitalize on the transformative power of green IS, the primary goal is to design and implement business processes that are eco-effective, that is, are not environmentally harmful at all.

These conjectures have a number of implications for both research and practice. From an academic point of view, we need to shed further light on how sustainability initiatives and transformations are understood by organizations, and what role IS can play in not only enhancing efficiency but indeed contributing to eco-effectiveness.

From a practice point of view, organizations should be clear about the actual potentials proffered by IS to transform these organizations towards eco-effectiveness, and thus positively impact on their balance sheet. There are now many examples of where organizations have deeply integrated sustainability into their business models, where "trade-offs between economic development and environmentalism aren't necessary. Rather, the pursuit of sustainability can be a powerful path to reinvention for all businesses facing limits on their resources and their customers' buying power" (Haanaes et al. 2013).

From our point of view, it is worrying that our sample suggests that the majority of organizations appear not to strive for eco-effectiveness at all, and we see this is a major challenge for both the academic IS discipline as well as organizational practice.

Conclusion

In this paper, we provide evidence that IS support the development of eco-efficiency, eco-equity, and eco-effectiveness through their capabilities to automate, inform, and transform. We analyzed interviews with experts on environmental sustainability in organizations. However, our study indicates that organizations have not yet fully grasped the full transformative power of IS in fundamentally changing business models and business processes towards eco-effectiveness.

The main limitation of this work is its small sample size. Still, through the selection process, we aimed to reach a broad spectrum of experts in different fields; however, this selection process is subjective in nature. Besides, we cannot exclude both respondent and researcher bias. However, we took care in corroborating our findings by including a second analyst into the interpretation of the interviews.

Grounded in our analysis, we have proposed two conjectures about the transformative power of IS, and how it relates to eco-effectiveness in particular, and we aim to further investigate the associated issues in our future research. We would also like to highlight that this is one of the rare cases where empirical evidence is provided for a theoretical model proposed in one of our journals. It is our belief that justifying conceptual knowledge is a critical task, particularly in fields of high societal relevance (Seidel et al. 2014).

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